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We will model stack inspection using the (subset of) ABLP logic described below. The language contains

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  - $P \wedge Q$ says s means that both P and Q say s.
  - $P \Rightarrow Q$ means that P speaks for Q, i.e. P has at least as much authority as Q.

We assume a set of atomic statements and atomic principals.

principal P ::=

$AtomicPrincipal$

$P_1 \wedge P_2$

$P_1 \mid P_2$

statement s ::=

$AtomicStatement$

$\mathsf{s}_1 \wedge \mathsf{s}_2$

$\mathsf{s}_1 \rightarrow \mathsf{s}_2$

P says s_1

$P_1 \Rightarrow P_2$

Example Given some s we define following new statements.

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For this we require certain rules (axioms) for making proofs.

Axioms about statements

1 *If* `s` *is an instance of a theorem of propositional logic then* `s` *is true in ABLP logic.*

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The ABLP statement

$$(P \text{ says } \mathsf{s}) \wedge ((P \text{ says } \mathsf{s}) \to \mathsf{s}) \to \mathsf{s}$$

is an instance of the propositional logic statement

$$(X \wedge (X \to Y)) \to Y$$

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is an instance of the propositional logic statement

$$(X \wedge (X \longrightarrow Y)) \longrightarrow Y$$

Hence both ABLP statements are true.

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We can draw conclusions from statements made by principals.

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We can draw conclusions from statements made by principals.

4 *If* s *then* P says s *for every principal* P*.*

True ABLP statements are supported by all principals.

Example

Given statement *Alice* says $(\mathsf{s}_1 \wedge \mathsf{s}_2)$ how do we conclude that *Alice* says s_1.

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We use the following steps.

$(\mathsf{s}_1 \wedge \mathsf{s}_2) \longrightarrow \mathsf{s}_1$	by (1)
Alice says $((\mathsf{s}_1 \wedge \mathsf{s}_2) \longrightarrow \mathsf{s}_1)$	by (4)
Alice says s_1	by (3)

Axioms about principals

5 $(P \wedge Q)$ says s $\equiv (P$ says s$) \wedge (Q$ says s$)$

6 $(P \mid Q)$ says s $\equiv P$ says $(Q$ says s$)$

7 $(P = Q) \rightarrow (P$ says s $\equiv Q$ says s$)$

$=$ is equality on principals.

8 $(P_1 \mid (P_2 \mid P_3)) = ((P_1 \mid P_2) \mid P_3)$

Quoting is associative.

9 $(P_1 \mid (P_2 \wedge P_3)) = (P_1 \mid P_2) \wedge (P_1 \mid P_3)$

Quoting distributes over conjunction

10 $(P \Rightarrow Q) \equiv (P = P \wedge Q)$

11 $(P \text{ says } (Q \Rightarrow P)) \rightarrow (Q \Rightarrow P)$

A principal is free to choose a representative.

Example We want to conclude s from the three statements:

- $(Alice \wedge Bob)$ says $(Charlie \Rightarrow (Alice \wedge Bob))$
- $Charlie \mid Alice$ says s
- $(Alice$ says s$) \rightarrow$ s

$$(Alice \wedge Bob) \text{ says } (Charlie \Rightarrow (Alice \wedge Bob))$$

$$\rightarrow (Charlie \Rightarrow (Alice \wedge Bob)) \qquad \text{by (11)}$$

$$(Charlie \Rightarrow (Alice \wedge Bob)) \qquad \text{by (2)}$$

$$Charlie = (Charlie \wedge Alice \wedge Bob) \qquad \text{by (10)}$$

$$Charlie \text{ says } (Alice \text{ says s}) \qquad \text{by (6)}$$

$$(Charlie \wedge Alice \wedge Bob) \text{ says } (Alice \text{ says s}) \qquad \text{by (7,2)}$$

$Alice$ says ($Alice$ says s) by (5,1,2)

$Alice$ says (($Alice$ says s)$\rightarrow$s) by (4)

$Alice$ says s by (3)

s by (2)

Modeling Java stack inspection using ABLP

Wallach, Felten, 1998

Code can be digitally signed by a signer. We treat code, public keys and signers as principals. Stack frames created during execution of code are also treated as principals. Targets (resources to be protected) are also treated as principals.

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If K is a public key of S then we have the statement

$$K \Rightarrow S \tag{S1}$$

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If K is a public key of S then we have the statement

$$K \Rightarrow S \tag{S1}$$

If some code C was signed and K is the corresponding public key then we have the statement

$$K \ \mathsf{says}\ (C \Rightarrow K) \tag{S2}$$

If F is the stack frame generated for executing code C then we have the statement

$$F \Rightarrow C \tag{S3}$$

Frame credentials Φ = set of all valid statements of the form S1,S2 and S3.

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Note that from K says $(C \Rightarrow K)$ using (11) we can conclude $C \Rightarrow K$.

Further we can show transitivity of $\Rightarrow$: given $A \Rightarrow B$ and $B \Rightarrow C$ we have:
$A = A \wedge B$ by (10)
$B = B \wedge C$ by (10)
Hence $A = A \wedge B \wedge C = A \wedge C$
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Hence from S1, S2 and S3 we can conclude $F \Rightarrow S$.

For each target T we treat $\mathsf{Ok}(T)$ as an atomic statement.

It means that access to T is permitted.

We consider the axiom

$$(T \text{ says } \mathsf{Ok}(T)) \rightarrow \mathsf{Ok}(T) \tag{S4}$$

A target is always free to grant permission to itself.

Targets are dummy principals. They never speak, but other (non-dummy) principals representing them may speak for them.

Target credentials $\mathcal{T}$ is the set of such axioms for all targets T.

Policy for a virtual machine M is defined by a set access credentials $\mathcal{A}_{\mathsf{M}}$ of statements of the form $P \Rightarrow T$ where P is a principal and T is a target.

This rule means that the local policy of virtual machine M allows P to access T.

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During execution, at any point of time, a stack frame F has a belief set $\mathcal{B}_F$

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Starting the program For the initial stack frame F_0

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If stack frame F calls $\mathsf{enablePrivilege}(T)$ then we update: $\mathcal{B}_F := \mathcal{B}_F \cup \{\mathsf{Ok}(T)\}$.

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Function calls

Function call from stack frame F creates a new stack frame G.

$\mathcal{B}_G = \{F \text{ } \mathsf{says\ s} \mid \mathsf{s} \in \mathcal{B}_F\}$.

Disabling privileges

If stack frame F calls disablePrivilege(T) then we update

$\mathcal{B}_F := \mathcal{B}_F \setminus \{\mathsf{s} \mid \mathsf{Ok}(T) \text{ occurs in } \mathsf{s}\}$

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If stack frame F calls $\mathsf{revertPrivilege}(T)$ then we update $\mathcal{B}_F := \mathcal{B}_F \setminus \{\mathsf{Ok}(T)\}$

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Checking privileges

When F calls $\mathsf{checkPrivilege}(T)$ then we check that $\mathsf{Ok}(T)$ can be concluded from the set

$\Phi \cup \mathcal{T} \cup \mathcal{A}_{\mathsf{M}} \cup \{F \ \mathsf{says}\ \mathsf{s} \mid \mathsf{s} \in \mathcal{B}_F\}$.

Example Assume at the beginning that $\mathcal{B}_{F_1} = \{\}$.

Now F_1 calls $\mathsf{enablePrivilege}(T_1)$. We have $\mathcal{B}_{F_1} = \{\mathsf{Ok}(T_1)\}$.

F_1 calls $\mathsf{checkPrivilege}(T_1)$.

Hence we take the statement F_1 says $\mathsf{Ok}(T_1)$.

Let S_1 be the signer of the code which produced the frame F_1.

Then we conclude $F_1 \Rightarrow S_1$ from the frame credentials Φ.

If the access credentials set $\mathcal{A}_{\mathsf{M}}$ has a statement $S_1 \Rightarrow T_1$

then using the statement $(T_1 \text{ says } \mathsf{Ok}(T_1)) \rightarrow \mathsf{Ok}(T_1)$ from T

we conclude $\mathsf{Ok}(T_1)$.

Now F_1 makes a function call and the new frame F_2 calls $\mathsf{enablePrivilege}(T_2)$.

We have $\mathcal{B}_{F_2} = \{F_1 \text{ says } \mathsf{Ok}(T_1), \mathsf{Ok}(T_2)\}$

F_2 makes function call and the new frame F_3 calls $\mathsf{disablePrivilege}(T_1)$.

We have $\mathcal{B}_{F_3} = \{F_2 \text{ says } \mathsf{Ok}(T_2)\}$.

F_3 makes function call and the new frame F_4 calls $\mathsf{enablePrivilege}(T_2)$.

We have $\mathcal{B}_{F_4} = \{(F_3 \mid F_2) \text{ says } \mathsf{Ok}(T_2), \mathsf{Ok}(T_2)\}$.

F_4 calls $\mathsf{revertPrivilege}(T_2)$.

We have $\mathcal{B}_{F_4} = \{(F_3 \mid F_2) \text{ says } \mathsf{Ok}(T_2)\}$.

Now F_4 calls $\mathsf{checkPrivilege} T_2$.

We take the statement $(F_4 \mid F_3 \mid F_2)$ says $\mathsf{Ok}(T_2)$ i.e.

F_4 says $(F_3$ says $(F_2$ says $\mathsf{Ok}(T_2)))$.

Suppose from the frame credentials Φ imply that

$F_4 \Rightarrow S_4 \quad F_3 \Rightarrow S_3 \quad F_2 \Rightarrow S_2$

Suppose that $\mathcal{A}_{\mathsf{M}}$ further has statements

$S_4 \Rightarrow T_2 \quad S_3 \Rightarrow T_2 \quad S_2 \Rightarrow T_2$

Then we conclude:

T_2 says $(F_3$ says $(F_2$ says $\mathsf{Ok}(T_2)))$
T_2 says $(T_2$ says $(F_2$ says $\mathsf{Ok}(T_2)))$

T_2 says (T_2 says (T_2 says Ok(T_2)))

Further (T_2 says Ok(T_2))$\rightarrow$Ok(T_2) is in $\mathcal{T}$.

Hence T_2 says (T_2 says ((T_2 says Ok(T_2))$\rightarrow$Ok(T_2))).

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Similarly T_2 says Ok(T_2).

Hence Ok(T_2).